

Comparative evaluation of bond strength of different dual cure composite core materials with glass fiber post: An in-vitro study

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Abstract:

Aim: To evaluate the retention of glass fiber dental post embedded in three different types of dual cure core materials namely, Luxacore Z, Compcore AF and Corecem.

Materials and method: Ninety prefabricated fiber reinforced posts (D.T. light Posts) were taken and divided into three groups. The post surface was treated with silane coupling agent (Monobond-S, Ivoclar-Vivadent Schaan, Liechtenstein) as per the manufacturer's instructions. Bonding agent (Prime and Bond-Dentsply, U.S.A.) was applied on post surface with brush and cured according to manufacturer's instructions. Each of the three core build-up materials were manipulated according to the respective manufacturer's instructions and a core of 4 mm core height was prepared by using prefabricated matrix. Thirty specimens for each core build up materials were made. The specimens were divided into the following groups each containing 30 samples (Group I - Luxacore Z, Group II-

Compcore AF, Group III – Corecem). The data was analyzed using SPSS (version 20). One Way ANOVA and Tukey's post hoc multiple comparison test were applied for statistical analysis.

Result: In the present study, Luxacore Z showed greater retention value with glass fiber post (15.64 MPa) in comparison to Compcore AF (14.99 MPa) and Corecem (14.33 MPa) core resins.

Conclusion: The retentive strength of dual cure resin Luxacore Z to the glass fiber post is significantly higher than dual cure resin Compcore AF and Corecem.

Keyword: bond strength, composite, glass fibre post, post and core,

Introduction

Growing attention needs to be given to procedures carried out after completion of the endodontic treatment and their impact on the prognosis of devitalized teeth.^[1] The health and the successful clinical outcome of endodontically treated teeth depends significantly more on the coronal restoration than on the technical quality of the endodontic treatment.^[2-6] However, the functional restoration of a devitalized tooth is a challenge to the dentist because the forces on these teeth and adjacent tissues are typically induced by internal stresses.⁷ Endodontically treated teeth can be restored to their original function with the use of intra-radicular devices. A post and core system contribute in providing predictable restorative options for severely mutilated, endodontically treated teeth. These devices may vary from a conventional traditional custom cast-post and core to one visit techniques, using commercially available prefabricated post systems.^[8-10]

To overcome certain disadvantages associated with the conventional metal post system and a rising demand for tooth-colored restorations, led to the introduction of prefabricated glass fiber posts. Since its introduction, a sustained effort has been made to improve the bonding potential of current adhesive systems to the post and core in a restoration. Although, the dentin/cement interface is a key factor for long-term clinical success of a luted post to root dentin, the glass fiber post/core interface also requires attention, as several studies pinpointed this interface as the weak link in the adhesion process.^[11-13]

Resin composites when used as a core material offer various advantages such as being most aesthetically acceptable restorations, they do not darken the teeth like conventional metal posts and have acceptable strength. These composites are also selected for colour contrast against tooth structure to facilitate tooth preparation for crowns. Also, using dentinal adhesives composites can be bonded to teeth. For convenience, dual-cured materials can be selected, as they set quickly, the core and tooth preparations can be completed without delay.^[7]

The core material should considerably adapt and create a uniform and tight inter diffusion zone between the post and core and should achieve structural continuity and homogeneity with the post surface, hence increasing bond strength. The bond strength between fiber post and core material is one of important criterion for selection of a core material. However few studies show that demonstrated that the interface between fiber posts and core materials were weaker compared to that between core materials and

dentin.^[12,13] Thus, the present study was planned and aimed to compare the retention of three types of dual cure composite resin core build up material (Luxacore Z, Compcore AF, Corecem) to the prefabricated glass fiber dental post head (RTD).

Materials and method: The core build up materials and their corresponding bonding systems were supplied by the same manufacturer. The tapered glass fiber posts (RTD Saint, Egreve, France) of diameter 1.80 mm and length 20 mm was selected to simulate the length and post space of the anterior teeth. The prefabricated matrix used for making the specimens was standardized to the selected diameters, which correspond to the maximum mesio-distal widths of natural anterior teeth measured at the level of the cemento-enamel junction after crown preparation.^[14]

Pre-fabricated mould to facilitate core build up: For the core build-up procedure, each post was positioned upright on a glass slab, in a hole with diameter equal to post diameter and secured with a drop of sticky wax. The post was positioned in the exact center of a cylindrical pre-fabricated matrix, 10 mm in diameter and 4 mm in height, to ensure that the post diameter remained constant throughout the core length.

Specimen preparation: For this study, 90 prefabricated fiber reinforced posts (DT Light Post) were taken and divided into three groups. All the specimens used in the study were prepared using the same mould, so that variability of post and core dimensions did not have any influence on the retention of the tested specimens. Group I specimens were fabricated with dual cure resin core material (LuxacoreZ) after the post surface was cleaned with water spray to remove dust particles & then air dried and treated with silane coupling agent (Monobond-S, Ivoclar-VivadentSchaan, Liechtenstein) And Bonding Agent (Prime And Bond-Dentsply, U.S.A.). Group II specimens were made with dual cure resin core (Compcore AF) material after the post surface was cleaned with water spray to remove dust particles and then air dried and treated with silane coupling agent (Monobond-S, Ivoclar-VivadentSchaan, Liechtenstein) and followed by the application of bonding agent (Prime And Bond-Dentsply, U.S.A.). Group III specimens were made with dual cure resin (Corecem) core material after the post surface was cleaned with water spray to remove dust particles and then air dried. Silane coupling agent (Monobond-S, Ivoclar-VivadentSchaan, Liechtenstein) and bonding agent (Prime And Bond-Dentsply, U.S.A.) was applied on the post head for 20 seconds with vivapen brush as per the instructions given by the manufacturers. The excess amount was dispersed with a stream of air until a glossy, immobile liquid film resulted. The post was then placed into the mould and light cured for 10 seconds at an intensity of more than 500 mw/cm², according to the instructions of the manufacturer. A core of 4 mm core height was prepared using a prefabricated matrix.^[14] Thirty specimens were made for each core build up material. The specimens were divided into the following groups:

- Group I- Luxacore Z with glass fiber post - 30 samples
- Group II- Compcore AF with glass fiber post - 30 samples
- Group III - Corecem with glass fiber post - 30 samples

Testing the specimen: The standardized dimension of the specimens was measured verified using a verniercaliper (AMBA Instruments). The specimens were stored in distilled water at 37 degree centigrade for 24 hours to simulate oral conditions, following which they were subjected to retention tests in a universal testing machine (Star Testing System, Model No. 880t) at a loading speed of 5mm/minute. Post-core retention was determined by recording the tensile force required to dislodge the post from the core material. Failure load was registered in MPa (Megapascal). The tensile bond strength at the glass fibre post-core interface of three different core build-up materials was studied using a universal testing machine.^[15] Each specimen was placed within the jig such a manner that, only the core remained in the jig while the free end of the post projected out to fit into the Universal Testing Machine. Tensile load, parallel to the long axis of the post, was applied at a crosshead speed of 5 mm/min to test its retention. The maximum failure load was recorded in Newton and then converted into MPa. The maximum stress was calculated by dividing the recorded peak load by the computed surface area. The height (h) of each specimen was measured and radius of each post was standardized at 0.9 mm as prefabricated posts were used. In order to calculate the exact bonding surface area, the formula for a cylinder ($2 \pi r h + 2 \pi r^2$) was used, since the parallel part of the tapered posts were inserted into the core cylinder.^[13]

Statistical analysis: The data was analyzed using the computer software, Statistical Package for Social Sciences (SPSS) version 20. The mean and standard deviation were calculated of all the groups. Analysis of variance (One Way ANOVA) was performed as the parametric test to compare the three groups. Tukey's post hoc multiple comparison test was used to find out any differences between subgroups and for pair wise comparisons. The data was interpreted at a confidence interval of 95% and the levels of significance were as follows: $p \geq 0.05$ – Not significant; $p < 0.05$ – Significant; $p \leq 0.001$ – Highly significant.

Results: Table 1describesthe tensile load values (MPa) for the retention of the dual cure composite resin core (Luxacore Z) to the glass fiber dental post. The mean value of failure load is 15.64 ± 1.52 (MPa) with 95% values varying from 15.07-16.21. The similar data for Group II and Group III are described in tables 2 and 3 respectively. The mean value of failure load was 14.99 ± 1.11 (in MPa) with 95% values varying from 14.56-15.40 for Compcore AF. While for Corecem composite resin to the glass fiber dental posts the mean value of failure load was 14.33 ± 1.69 (MPa) with 95% values varying from 13.69-14.96.

Table-(1): Retention values (in MPa) of dual cure composite resin core (LUXACORE Z) to the glass fiber dental posts

Number of Samples	Mean (MPa)	StandardDeviation	95 % Confidence Interval for Mean		Minimum (MPa)	Maximum (MPa)
			Upper bound	Lower bound		
30	15.64	1.52	16.21	15.07	11.63	19.11

Table-(2): Retention values (in MPa) of dual cure composite resin core (COMPCORE AF) to the glass fiber dental posts

Number of Samples	Mean (MPa)	Standard Deviation	95 % Confidence Interval for Mean		Minimum (MPa)	Maximum (MPa)
			Upper bound	Lower bound		
30	14.99	1.11	15.40	14.56	12.64	16.65

Table-(3): Retention values (in MPa) of dual cure composite resin core (CORCEM) to the glass fiber dental posts

Number of Samples	Mean (MPa)	Standard Deviation	95 % Confidence Interval for Mean		Minimum (MPa)	Maximum (MPa)
			Upper bound	Lower bound		
30	14.33	1.69	14.96	13.69	10.23	17.00

Table 4 describes the comparison of the mean retention values (MPa) between group I, group II and group III (Graph 1). Group I shows higher value than group II and group III.

Table-(4): Comparison of the retention values (in MPa) between group I, group II & group III.

Group s	Number of Samples	Mean (MPa)	Standard Deviation	95% Confidence Interval for Mean		Minimum (MPa)	Maximum (MPa)
				Upper bound	Lower bound		
I	30	15.64	1.52	16.21	15.07	11.63	19.11
II	30	14.99	1.11	15.40	14.56	12.64	16.65
III	30	14.33	1.69	14.96	13.69	10.23	17.00

Graph 1: Comparison of means of failure loads (in Mpa) recorded in 3 groups with fiberpost

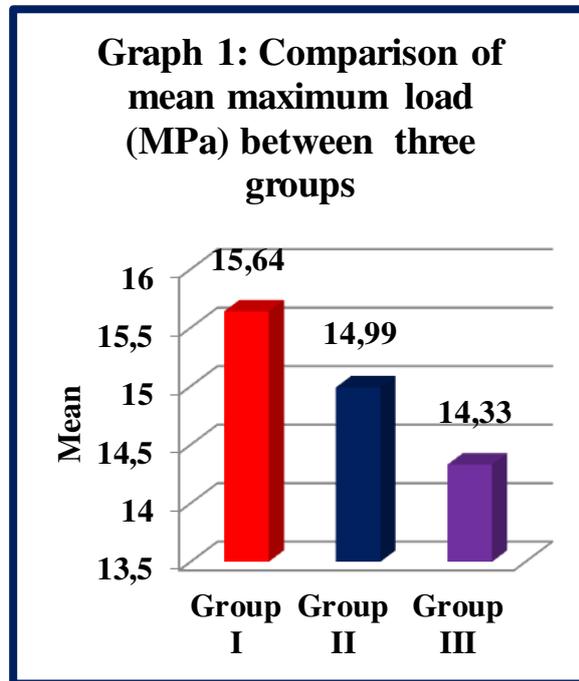


Table 5 shows the mean maximum load comparing the retention of the three groups. It shows significant difference between the groups, with the least value being that of group III followed by group II and highest in that of group I.

Table-5: Analysis of variance (One Way ANOVA) of mean maximum load (MPa) comparing three groups.

Group	Mean	± SD	F value	P* value
Group I	15.64	1.52	6.035	< 0.004
Group II	14.99	1.11		
Group III	14.33	1.69		

*P value derived from One Way ANOVA test

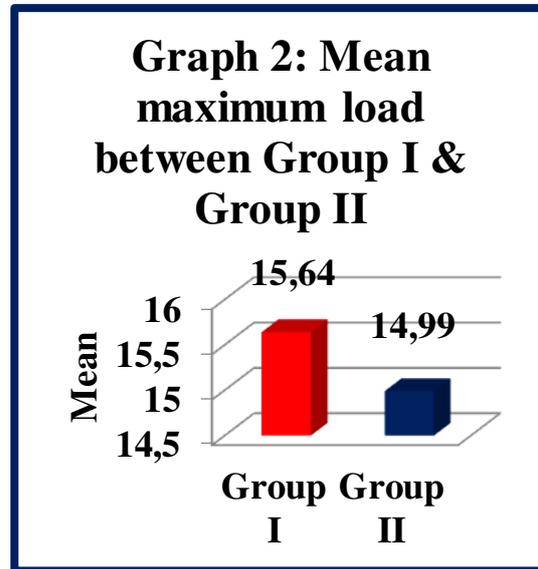
Tukey's post hoc multiple comparison test shows there is no significant difference between group I and group II (P value 0.198) (Graph 2) as well as between group II and group III (P value 0.203) (Graph 4) but a statistically significant difference is found between group I and group III (P value 0.002) (Graph 3) (Table-6).

Table-6: Tukey's post hoc multiple comparison test

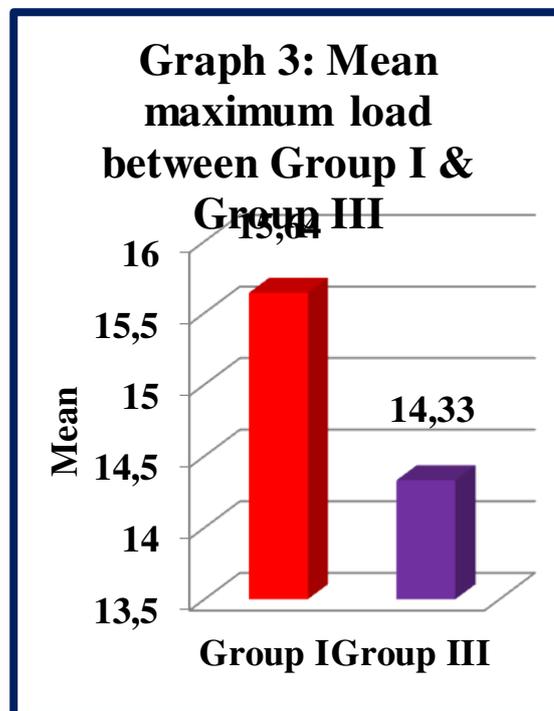
Group	Mean	P value
Group I vs Group II	15.64 vs 14.99	0.198
Group I vs Group III	15.64 vs 14.33	0.002

III	Group II vs Group	14.99 vs 14.33	0.203
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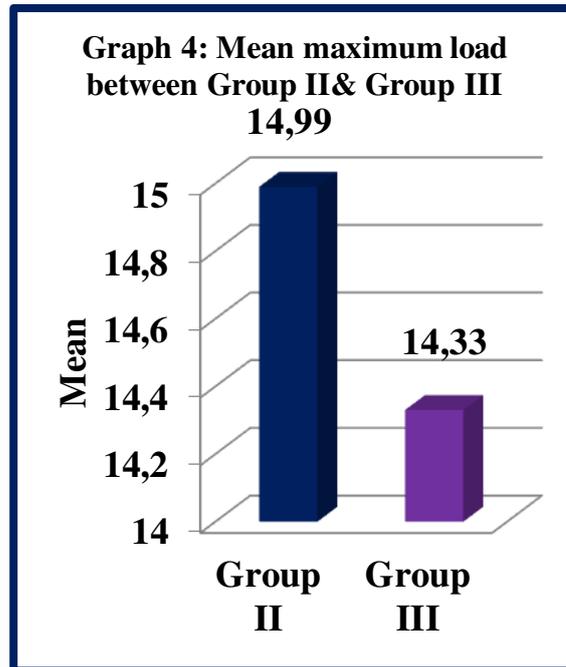
Graph 2: Comparison of means of failure loads (in Mpa) recorded in group I and group II with fiberpost



Graph 3: Comparison of means of failure loads (in Mpa) recorded in group I and group III with fiberpost



Graph 4: Comparison of means of failure loads (in Mpa) recorded in Group II and group III with fiberpost



Discussion:

The restoration of endodontically treated teeth with metal free and physio-chemically homogenous materials that have mechanical properties similar to dentin has become a major objective in dentistry. Reconstructing the endodontically treated teeth with prefabricated fiber post and core systems has been widely accepted as a treatment option offering both esthetics and function. These systems can reduce the incidence of non-retrievable root fractures when compared to the prefabricated metallic posts or conventional cast posts. Fiber posts are currently perceived as promising alternatives to cast metal posts, as their elastic modulus (13-40 GPa) is similar to that of dentin, producing a favorable stress distribution so that the post may act as a shock absorber. They also have more esthetic outcomes for the endodontically treated anterior teeth. Glass fiber posts have a high aesthetic potential, are highly translucent and thus give more life-like appearance to prosthesis, and they are easy to remove when endodontic retreatment is required.^[14,16,17]

Within last 30 years, assorted research has been done in the field of post and core restorations and on various aspects associated with them. A study conducted in 2011 has shown that endodontically treated teeth with no post and core system had stresses concentrated along the cervical third of the labial surface of the tooth.^[18]

Various studies have shown that the bond strength of packable composites is lower than that of the flowable composites.^[12,13,19-21] The lower bond strength of the packable composite can be attributed to insufficient adaptation of the high viscosity composite around the post. The high force of condensation of the packable composite that applies stresses to the post-core interface causes reduction in bond strength. It also shows more voids and porosities

in comparison to flowable composite.^[21] However, this wasn't the area of concern in the present study.

Studies have reported that, placing a bonding agent between the glass fiber post and dual cure resin core showed increase in bond strength both micromechanical and chemical bonding by enhancing post surface wetting.^[11,14,23,24]

Different theories have been proposed in order to elucidate the bonding mechanism through silane coupling agents. The chemical bonding theory states that the coupling action of the silane involves the formation of covalent bond from the reaction of organo-functional group (R) and the hydrolyzed alkoxy groups (R'O)₃, respectively with the resin matrix and mineral substrate (glass or silica) of the composite material. The reversible hydrolytic bond mechanism theory is more widely accepted as it provides a more robust explanation for the hydrolytic stability of bonding through silanes. The speculations states that the bonds between silane and mineral substrate are reversibly broken and remade within the presence of water, permitting stress relaxation without loss of adhesion.^[25]

Only the silane agent can chemically bridge resins and OH-covered inorganic substrates, at the fiber post-composite core interface, thus permitting the chemical bond only between the resin of the core material and the exposed fibers of the post. While, the highly cross-linked polymers of the matrix in FRC posts shows absence of any functional group available for reaction. The prefabricated FRC posts do not contain semi-IPN structures. Since the contribution of the chemical bond in coupling post and core materials through silanes can be expected to be low, the mechanism possibly concerned in the enhancement of the post-core bond seen in the present study can be identified in the improvement of post surface wettability following silane coating.^[25]

In the present study, we have compared three composite core build up materials with some structural and chemical differences. When the comparison was made between these three groups, mean values showed a definitely significant difference with $p < 0.004$ between the groups with least value in group III followed by group II and highest in group I as inferred from Analysis of variance (One Way ANOVA) (Table 5/Graph 1). Tukey's post hoc multiple comparison test (Table-6) revealed that the retentive strength of dual cure resin core Luxacore Z to the glass fiber post group is significantly higher than dual cure resin core Corecem for which retention was lowest.

One of the composite resin ingredients which affects the mechanical properties, is the filler size, type and content. LUXACORE Z has 71% filler content by weight while COMPCORE AF has 77% by weight and CORECEM has 66% by weight. It was also considered that the percentage of fillers in these composite resins was not the only factor that affected the tensile strength, since composite resins with almost the same filler did not have the same strength. It seemed that there were other factors like degree of conversion, filler-matrix bond in the oral environment, type of polymerization, polymerization shrinkage and many other factors which affected the mechanical properties of composite resins. Thus, the difference in retention value among these dual cure composite core materials may be due to

the difference in their handling characteristics, compositions (such as matrix type, filler type, filler load) and properties (such as polymerization ability, flexural strength, hardness). These differences may have an effect on their adhesion to tooth substrate.^[22,26]

Result of our study was in corroboration with the results of Sadek et al, Salehmawho have evaluated the bond strength performance of different composites resin used as core materials around fiber posts.^[20,27] Sadek et al did a study to evaluate the microtensile bond strengths of different resin composites used as core materials around fiber posts. The study concluded that core build-up and hybrid composites are better alternatives to flowable composites as core build-up materials.^[27] Ziad Salem et al did a study to evaluate the bond strengths between various composite resin core materials (Multicore Flow, Ivoclar-Vivadent; Tetric Flow, Ivoclar-Vivadent; Filtek Flow, 3M-ESPE; Tetric Ceram, Ivoclar-Vivadent; Filtek Z250, 3M-ESPE), and an FRC post (FRC Postec Plus, Ivoclar-Vivadent) by means of the microtensile nontrimming technique. They concluded that for core buildup on a fiber post, dual-cure composites appear to be preferable to light-curing composites.^[20]

Aksornmuan et al did a study to evaluate the microtensile bond strength (μ TBS) of a dual cure resin core material to different regions of fibre posts using different surface treatments. Silica zirconium glass fibre posts (Snowpost) and quartz fibre posts (Aestheti-Plus) were used. They concluded that, the bond strength between fibre post and dual-cure resin core material depends upon the type of post and surface treatment. There were no regional differences in μ TBS of the bonded post.^[22]

Zahra Khamverdi et al did an in vitro study to assess the microtensile bond strength of quartz fiber posts to different composites, and to composite combinations used as core materials. Their study revealed that no significant difference was found between the bond strengths of microhybrid and flowable composites.^[19]

However, Zhang Y. et al conducted a study to evaluate the microtensile bond strength of posts to light or dual cured resin core materials and concluded that bonding between fiber posts and resin core material is affected by fiber type but type of dual cure resin has no effect on post and core bonds for any of three posts used in study.^[26] This was slightly in contrast to the results of the present study. Fayaz Ahmed et al did a study to evaluate the microtensile bond strength of a low viscosity flowable resin composite and two different highly filled resin composites core materials. They concluded that, flowable composites appear to be preferable to light-activated nano-composite or self-cure composite materials as core build-up materials.^[21]

However, in-vitro studies are usually used to test materials and techniques before clinical application. Although considered generally of low clinical relevance, it is clear that results obtained in vitro are useful to guide protocols for several clinical approaches, especially considering the absence of evidence from well-designed clinical trials in dentistry. As this was an in-vitro study, the tests do not simulate the clinical situations. The materials

might perform differently in clinical situations. The forces utilized for testing the material are far harsher than the actual forces seen in the oral cavity. In the oral cavity, the tensile force is one of the many masticatory forces. Situations in which only pure tensile stresses are being applied are not very common. In addition, the post and core is covered by a crown clinically, that tends to distribute the masticatory stresses more evenly to the surrounding periodontium. Therefore this study gives us a relative order of the property of the material being tested.

Conclusion: According to the results obtained, the present study states that retentive strength of dual cure resin Luxacore Z (15.64 MPa) to the glass fiber post is significantly higher than other dual cure resins Compcore AF (14.99 MPa) and Corecem (14.33 MPa).

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